IAPA Scholarship Research Paper

Permeable Asphalt Application and Technology

Zachery Burks

Undergraduate Civil Engineering Student

Southern Illinois University Carbondale

Acknowledgement

I would like to thank the Illinois Asphalt Pavement Association for investing in my education and giving the opportunity for me to further my education with less concern about my financial need. That means a lot to me and is something I do not take for granted. I will continue to work hard and do my best throughout the remainder of my education.

I would also like to thank Southern Illinois University's Carbondale College of Engineering administration and outreach. They do a great job of making students aware of opportunities and keeping us engaged. I am very thankful to learn under such an encouraging and helpful group of people.

Table of Contents

Abstract

The objective of this paper is to research and study the application of permeable pavements and what benefits that has on the area of application. This paper will briefly get into design aspects of the asphalt and how it is constructed. It is important to know the reasoning behind, advantages, and disadvantages of the application to accurately determine the validity of implementing this technology under varying circumstances. The goal in mind is to clearly define where and what situations porous pavement should be used for as well as discuss the practicality of implementation. Another goal in mind is to discuss the advancement of this technology and how that may change the applicability of this concept.

Introduction

In densely populated and urban areas, storm water runoff has been an issue for several reasons. Pollution of streams, rivers, and other bodies of water is the first of those reasons. The second is controlling and directing large volumes of water. When the runoff in a city or urban area flows into a drain, it must be directed through pipes to a stream or other body of water. Getting the water there is easier said than done, especially in a city where impervious barriers are everywhere you look and all that storm water has to go somewhere.

An environmentally sound solution to these issues is permeable pavement. The basic concept of permeable pavement is the surface of the barrier has pores which allow water to penetrate the barrier and flow down through several layers into a reservoir where the water is stored until it can be absorbed into the earth. This method has the potential to greatly reduce the amount of storm water that must be directed through sewers and pipes and also reduces the amount of pollution that ends up into our bodies of water *(Crump 2020).*

Analysis

This technology and fairly new method has been used and implemented in several states and large-scale projects. The effect it has had has been just as expected. However, most of these experiments and implementations are on areas with no high volume of traffic. There are plans in California to possibly implement permeable asphalt on highway shoulders, but there is no data from that case study to present at this time *(Kayhanian, Li, Harvey, and Liang 2019).*

A major component of permeable pavement that is in question is its durability. As aforementioned, testing of this concept has mainly been conducted in parking lots or low-volume traffic areas. There is some skepticism amongst engineers about the durability of permeable pavement and its implementation into higher traffic areas. However, there are some engineers who advocate for pervious pavement saying that the thicker subbase of gravel and deeper sections of concrete or asphalt suggest that this method could be more durable than conventional pavement. This would be quite the breakthrough if proven correct and could mean more widespread implementation of this technology in high traffic, urban areas *(Stiffler, Mayer 2015).*

Another concern of pervious pavements that engineers have is the clogging of the pores. The surface layer of the permeable pavements having pores creates a possible issue with debris getting lodged in these pores and effecting the efficiency and effectiveness of the pavement. It is true that porous pavement requires some maintenance and extra planning. During new construction or landscaping projects, communities with pervious roads have laid geotech fabric down to catch mud and dirt. These communities have implemented policies about leaf litter cleanup and removal. They also hire a truck to clean and vacuum the roads as needed. Sure, this seems like a lot of planning and consideration, but when you think about where this technology's targeted implementation is, it is in congested areas where these policies are commonly already in place aside from the laying of the fabric over the road *(Stiffler, Mayer 2015).*

The benefits of this pavement use can far outweigh the cost and maintenance it requires. With the argument that pervious pavements could quite possibly be more durable than conventional pavement, the benefit rises even further. One benefit of this pavement is a return to a more natural hydrological cycle and balance. Reducing runoff also reduces the rate of discharge and pollution emitted through the storm water systems. Another advantage is the reduction in concentration of some pollutants. This can be done directly by the entrapment of the pollutant in the pavement or soil. It can also be done through chemical and biological processes that can occur in the pores and/or reservoirs under the permeable pavement. A further positive effect of this method is the reduction in temperature of urban runoff, which causes less stress on the environment that storm water is funneled to. One more benefit of pervious pavements is the reduced need for regional BMPs (detention ponds/reservoirs) which saves effort and money while allowing for more efficient use of urban space. A few more advantages apply specifically to areas where winters require some road maintenance. These include the pavement requiring significantly less salt spread for deicing and quicker thawing of snow and ice due to heat trapped in the pores of the asphalt (*Evaluating the Potential Benefits of Permeable Pavement on the Quantity and Quality of Stormwater Runoff).*

Aside from durability and maintenance, there are a few more concerns about the implementation of pervious pavements. One being the residence time of water in the reservoirs. In other words, how long must water sit before being soaked into the soil. This could be a major drawback, especially for areas that get a high amount of precipitation, if it takes an extended amount of time to penetrate the soil (*Evaluating the Potential Benefits of Permeable Pavement on the Quantity and Quality of Stormwater Runoff).* Another concern is applicability, which is a major focus of this paper. There are restrictions and limitations to where you can/should implement this kind of pavement. An example of these applicability restrictions is that it cannot be used on slopes greater than five percent and is recommended for gentle slopes only *(Un 2010)*. There are more of these applicability concerns that I will address in following sections.

Analysis of the technology reveals many things. This technology has major promise, but we have discovered that it has some drawbacks that need addressing. However, it revealed that porous pavements are an effective and efficient use of urban space that have many benefits including space efficiency and eco-friendly solutions. It also disclosed that this innovation may be on the verge of something big regarding its durability. The continued use and exploration of porous pavements is a promising venture for urban areas to consider.

Design

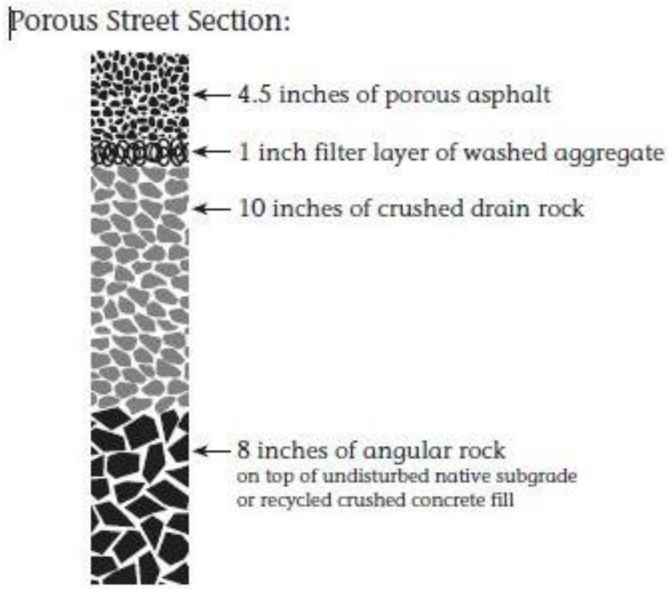
After analyzing this innovation, it is important to understand the design behind it to know why there are limitations to its application. It is also important because it allows better understanding of where implementation is suitable. It is important to note that design can vary based on location and material. The focus in this section will be standard design for porous asphalt. The design overview starts with the subbase and goes up by layer to the surface.

The first layer is 8 inches of angular rock. This is laid on top of undisturbed native subgrade or recycled crushed concrete fill. This is the bottom most layer of the street section and serves as part of the reservoir where water is held before it penetrates the soil. Before laying this layer, there is an option to use a geotextile fabric that helps maintain the gravel layer and trap pollutants. It can also help to prevent the gravel from settling. It is important to note here that it is recommended to limit the compaction of the native subgrade soil, as that can affect its ability and effectiveness to soak up the storm water *(Stiffler, Mayer 2015).*

The second layer is 10 inches of crushed drain rock. This layer functions as a secondary filter and part of the reservoir. It has the ability to store water should the layer below become full or backed up. This layer also provides a fair amount of support to the surface layer, as does the angular rock *(Stiffler, Mayer 2015).*

The next layer up is 1 inch of washed aggregate. This primarily serves as a filter for debris that made it through the pores of the surface layer. This can prevent the pollution of ground water and keep the layers below from getting clogged. This is the final layer before the surface layer *(Stiffler, Mayer 2015).*

The surface layer is 4.5 inches of porous asphalt. This is the layer of asphalt engineered to allow water to drain through it. Obviously, the surface is the layer that vehicles drive on. This porous layer is simply meant to allow water to drain through it and to function as the pavement. It is not meant to hold water and if it is, the pavement is malfunctioning. The following diagram shows the typical makeup of a porous street cross section *(Stiffler, Mayer 2015).*



Road diagram from Pringle Creek, courtesy of James Santana.

(Stiffler, Mayer 2015)

Application

A primary goal of this study was to outline the applicability of this subject. To do so, we must consider where it is needed, where it is effective, where it cannot be implemented, and how cost-effective it is in this location. These factors should be evaluated and used to determine where pervious pavements should be implemented.

A place where pervious pavements aren't needed and shouldn't be used are rural areas. Rural areas have the ability to cut ditches and control the flow of storm water more easily than urban and suburban areas. Also, pollution isn't as big of a concern in rural areas simply because there is less garbage or waste found on or near streets. Plus, in rural areas where farming is practiced, shedding the water into irrigation ditches benefits the crops. Once more, it isn't cost effective. Heavy farm equipment could tear up the road and damage the structure of the asphalt. Maintenance to keep porous pavements functional would cost significantly more in these areas. These reasons prove that penetrable pavement does not belong in rural areas.

Evaluating the validity of the application of porous pavement in urban and suburban areas is a bit more complex as it is more situational than the broad rural areas category. Suburban areas can still encounter farming fields near their outer edges. The regularity of heavy traffic on specific roads may discourage implementation there. If the water table is high in the area or if the slope is to large, implementation is impossible or restricted *(Un 2010)*. In the following definitions of applicability, it is assumed that the water table allows for implementation and that the slope allows for it as well. The goal is general definitions of applicability for varying areas of different population density and usage. However, it is important to note that other factors and restrictions could be at play.

Parking lots are a great place for implementation. They can be quite large and must shed a lot of water. Porous pavements allow water to enter the soil below, returning that area to a more natural hydrological cycle, reducing the amount of runoff that needs controlled, and causing a rejuvenation of the soil underneath the lots (*Evaluating the Potential Benefits of Permeable Pavement on the Quantity and Quality of Stormwater Runoff)*. Parking lots have been a primary focus for the testing and implementation of porous pavement for some time and should continue into the future.

Residential roads in congested areas are also a good avenue for implementation. These streets have less traffic and can be easily regulated and maintained. Residential roads in less congested areas are still a great option to implement this practice, but if farming is practiced in the area, it might be best to consult with the individuals who farm that land and consider if their practices would be affected by the application of this new pavement. Nonetheless, residential/low traffic areas are a great place for the application and further exploration of this technology.

High traffic roads in urban and suburban areas are a plausible application for porous pavements. There are many who question the durability of the pavement in these circumstances. However, as aforementioned in Analysis paragraph two, some say that porous pavements have the possibility to be even more durable than impervious pavements *(Stiffler, Mayer 2015)*. Generally speaking, higher traffic means more lanes, which in turns means more water that needs shed from the road and controlled into drains or other forms of runoff control. This is cause for the exploration of this technology on these roadways. In time, with the further exploration and experimentation of porous pavements, implementation on high traffic areas should become more common place.

Alleys can be a huge problem for one reason. They can accumulate a lot of waste and garbage, causing runoff to be polluted and harmful to the waterway or reservoir it is being led to. Alley ways, like parking lots, can most definitely be a suitor for porous pavement. It would greatly reduce the amount of waste that infiltrates runoff and durability isn't a concern because alleys do not attract much traffic. The only concern with application in alley ways is maintenance. Is it logistical to assume that the dumpsters, garbage cans, and miscellaneous objects that reside in an alley can be moved effectively to allow for the cleaning of the pavement? Would the high level of waste cause more frequent clogging of the pores and thus require more cleaning? Communication and clear scheduling could be the answer to these questions. The application of this technology in alleys is plausible and beneficial.

An area we have not mentioned yet in this study are walkways. Walkways are everywhere in urban and suburban areas. Porous materials would be a great alternative to the standard sidewalk or path. The lower weight and traffic that these paths see mean that the success of application isn't even in question. Many cities are already starting to take advantage of this greener and more sustainable method. Making this technology standard in the construction of walkways and paths in urban areas is a great step towards becoming more sustainable.

The application of porous pavements is becoming more widespread. Further exploration and experimentation in higher traffic areas might be the next step in the push for these more sustainable and environmentally friendly practices. If porous pavement can prove that it can be durable, the implementation of these pavements have the ability to become standard in urban and suburban areas.

Conclusion

The movement for the construction and implementation of more sustainable infrastructure is as important as ever. The world faces many environmental problems presently and the answer is sustainability. The application of porous pavements is very much a part of this movement.

The benefits of pervious pavements can greatly outweigh the cost. Preventing the pollution of waterways and reservoirs is easier said than done. The advantages of this technology are numerous and can increase our sustainability in an area of pollution control that is hard to approach. Pervious pavement is a feat of engineering that can be a vital solution for pollution control for the foreseeable future.

References

Crump, Wesley. "How Does Permeable Pavement Work?" Practical Engineering. October 06, 2020. Accessed July 26, 2021. https://practical.engineering/blog/2020/10/6/how-does-permeable-pavement-work.

Evaluating the Potential Benefits of Permeable Pavement on the Quantity and Quality of Stormwater Runoff. Accessed July 26, 2021. https://www.usgs.gov/science/evaluating-potential-benefits-permeable-pavement-quantity-and-quality-stormwater-runoff?qt-science_center_objects=0#.

Kayhanian, Masoud, Hui Li, John T. Harvey, and Xiao Liang. "Application of Permeable Pavements in Highways for Stormwater Runoff Management and Pollution Prevention: California Research Experiences." International Journal of Transportation Science and Technology. February 02, 2019. Accessed July 26, 2021. https://www.sciencedirect.com/science/article/pii/S2046043018301333.

Stiffler (@lisa_stiffler) on January 3, Lisa and M. Mayer. "The Porous Road Less Traveled." Sightline Institute. August 01, 2015. Accessed July 26, 2021. https://www.sightline.org/2012/01/03/the-porous-road-less-traveled/.

Un, Kit. "Fact Sheet: Permeable Paving." MAPC. November 09, 2017. Accessed July 26, 2021. https://www.mapc.org/resource-library/fact-sheet-permeable-paving/.